Amendments to the Specification

[0001] This application is a Continuation-in-Part of US Regular Patent Application 09/855,293 which was filed 14 May 2001, now ~~and will issue 8 July 2003 as~~ US Patent 6,589,405. It also claims benefit of PCT/US01/15531, filed 15 May 2000, from which the aforesaid application was derived. This application also claims benefit of US Provisional Patent Application 60/412,484 which was filed 20 September 2002.

[0002] ~~Aforesaid Appl. No. 09/855,293~~, US Patent 6,589,405, which is hereby incorporated by reference, describes a multilayered metal oxide coating which may beneficially be applied to an electrode of the kind provided herein and made of titanium to produce an anode that can used to electrolytically purify water by oxidizing pollutants dissolved in the water. ~~Aforesaid Appl. No. 09/855,293~~ US Patent 6,589,405 also describes a an electrochemical cell which is well suited for water purification applications and incorporates the electrodes provided herein.

[0016] Figure 2 shows a cathode advantageously used together with the anode of Figure 1, illustrating the use of nonconductive cords, meshes and spacers disposed between adjacent electrodes for improving electrical contact of the metallic fiber tow with the conductive substrate of the large surface area anode, while also improving electrical isolation between adjacent electrodes ~~including electrical contact enhancement means and electrical isolation means~~.

[0021] Another means for improving electrical contact ~~enhancement means~~ is illustrated in Figure 2, which depicts a cathode that can advantageously be used together with the anode of Figure 1 in an electrochemical cell like that described in US Patent 6,589,405. ~~related Patent Application No. 09/855,293.~~ Cathode 60 has the same dimensions as anode plate 20 shown in Figure 1, the same flow holes 28, and the same assembly bolt holes 30. Stainless steel and corrosion resistant nickel alloys such as Hastelloy are suitable cathode materials and, in the example illustrated, the cathode is a metal rectangle with no metallic fiber applied. Loops of braided polypropylene rope (six stranded, hollow core, 0.125 inch = 3.2 mm) are stretched along

the length of cathode 60 between flow hole 28 at the opposite ends. Preferably, the loops are secured by thermally fusing the ends of the polypropylene rope together. In the assembled cell, these loops of rope press the Ti-fiber against the anode plate, locking the Ti-fiber in place and ensuring good electrical contact. Water flows through the cell in a direction parallel with the loops of rope, which therefore do not interfere with water flow.

[0022] When installed in an electrochemical cell, the anodes depicted in Figure 1 will typically be pressed against cathodes similar to the one depicted in Figure 2. In this case, it ~~It~~ is necessary to provide ~~electrical isolation~~ some means to prevent direct electrical contact between the opposing anodes and cathodes and the short circuit that would thereby result. The preferred means for improving electrical isolation ~~means~~ comprises one or more rectangles 2 of fine plastic mesh cut slightly larger than the fiber wound area on the anode, and placed between the adjacent anodes and cathodes.

[0024] In order to provide improved electrical ~~Electrical~~ isolation between adjacent electrodes, ~~means in the form of~~ a cylindrical sleeve of plastic mesh 4 can be placed or fastened around either electrode, and preferably around the cathode as illustrated at the bottom of Figure 2. Spacers 6 made of plastic or another nonconductive rod or cord can conveniently be attached to mesh sleeve 4, ~~and serve as electrical contact enhancement means which~~ to press the fiber against the anode plate in the assembled cell, whereby electrical contact is improved.

[0034] The electrode structure provided herein largely avoids these various drawbacks and limitations. It is easy to manufacture, Ti-fiber tow is commercially available as well as Ni-fiber tow and stainless steel tow, undesirable cementation of the fibers is not excessive even when a thick slurry-type coating is applied, the structure has good mass transfer and current distribution properties, the active surface area is large, and the electrode it lends itself to compact and easily fabricated cell designs; for example, the electrochemical cell illustrated in Figures 4 and 5 in US Patent 6,589,405 ~~related Patent Application 09/855,293~~.

[0039] ~~Related Patent Application 09/855,293~~ US Patent 6,589,405 describes a suitable coating sequence to produce an anode that can be used to purify water by generating hydroxyl free radicals. First, a "precoat" layer comprising iridium dioxide and tantalum pentoxide is applied to the metal, followed by a "sealing coat" of tin dioxide doped with antimony, and finally the "slurry coat," which consists of particles of titanium dioxide doped with niobium in the +4 oxidation state cemented together with a matrix of titanium dioxide that is doped with antimony.

[0043] For example, an electrochemical cell incorporating anodes electrically connected in parallel and each having a fiber-wound area measuring 203mm x 368 on each side should have electrical resistance between the anode and cathode power connectors equal to at least 30 ohms ÷ N, where N is the number of anodes in the cell, and the resistance is measured with the cell fully assembled but dry. Mesh 2 which provides improved electrical isolation between adjacent electrodes ~~serves as the electrical isolation means~~ should be very sheer in order to minimize voltage drop in the electrolyte and minimize resistance to water flow; in fact, two layers of the finest meshes tested provided adequate electrical isolation as defined above. A mesh rectangle pressed directly against the anode is preferably made of polypropylene or another plastic which has good resistance to oxidation. A second rectangle of mesh adjacent to the cathode is conveniently cut from vent mesh made of vinyl coated fiberglass similar to window screen, but with openings about twice as large. A second polypropylene mesh rectangle can also be used. If two or more mesh rectangles cut from the same material are used, they should be cut with a different bias to prevent "locking" of the layers and possible interference with water flow.

[0057] The large surface area electrodes herein provided are advantageously used in an electrochemical cell with close spacing between the anodes and the cathodes, but they can also be used in an electrochemical cell or battery with wider spacing between the adjacent anodes and cathodes; for example, to allow the movement of water between vertically disposed electrodes by operation of convection instead of forced flow. In this case, mesh or another means for improving electrical isolation, ~~means~~ installed between the adjacent pairs of electrodes might not be necessary.

[0058] The quality of electrical contact needed between the fiber and the substrate plate will depend on the contact resistance. The contact resistance may be significant in a titanium anode with a electrocatalytic coating applied, making desirable the provision of some means to improve electrical contact ~~enhancement means~~ in order to improve the operation of the anode. In other cases, for example a cathode made of nickel with no coating applied, the contact resistance may be much smaller, whereby special means for improving electrical contact ~~enhancement means~~ may not be necessary.

[0059] Electrical isolation can be improved using separators of various kinds, ~~means of diverse form may be used,~~ so long as the material has suitably low electrical conductivity and usefully long service life. Suitable materials include polypropylene, polyethylene, EPDM rubber and other plastics or elastomers, as well as fiber glass mesh or cord or even short pieces of hard plastic or glass tubing or rod. Vinyl or vinyl-coated fiberglass cord could also be used, except that these materials should not be placed in large area contact with a titanium anode coated as described in US Patent 6,589,405. ~~related Patent Application 09/855,293.~~

[0060] The separators provided to improve electrical isolation ~~means~~ can be made of a wide variety of woven or nonwoven plastic or fiberglass mesh or cloth or another such electrically nonconductive and highly permeable material. In some cases nonconductive spacers (for example, polypropylene rope loops 32 in Figure 2) may provide sufficient electrical isolation between adjacent electrodes.

[0061] While the devices provided to improve electrical contact ~~enhancement means~~ are preferably made of electrically nonconductive material, whereby they ~~simulatancously~~ simultaneously serve to improve ~~as~~ electrical isolation ~~means~~, in some cases electrically conductive materials might also be used; for example, if mesh sleeve 4 is thick enough to reliably prevent direct contact of spacers 6 with the cathode plate 60 inside mesh sleeve 4, spacers 6 could be made by cutting pieces of titanium welding rod.